

Ultrasound imaging for measuring the material and mechanical properties of the Achilles tendon: inter-day reliability and correlation with a functional calf length test

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Purpose/Hypothesis: The ability to objectively assess Achilles tendon length and mechanical properties can be challenging because other factors such as muscle and joint mechanics can complicate standard clinical tests. Ultrasound imaging has the ability to provide isolated objective measures of the material and mechanical properties of the Achilles tendon. The primary aim of this study was to assess the inter-day reliability of the material and mechanical properties of the Achilles tendon in a single rater. A secondary aim was to investigate whether there was any relationship between measured tendon properties and calf muscle length measured with a lunge test.

Number of subjects: Ten Achilles tendons in 5 subjects (all subjects were 24 years old; 80% female).

Material/Methods: Healthy subjects attended 2 identical measurement sessions, 2 days apart. Subjects were measured at the same time of day and were encouraged to perform the same pre-test activities. Immediately prior to the ultrasound imaging, functional calf length was measured in standing with a lunge test. Subjects were then positioned prone with the knee extended and ankle held at 0 degrees of dorsiflexion, and measurements of the resting tendon length and tendon cross-sectional area were obtained from static ultrasound images. Tendon elongation was measured during isometric dynamometry through imaging the proximal movement of the musculotendinous junction of the medial gastrocnemius. Tendon strain was measured at maximum isometric torque. Intra-class correlation coefficients (ICCs) were calculated to determine the reliability of the ultrasound measures. The correlation between tendon properties and the lunge test were examined using a Pearson correlation coefficient, with the level of significance set at 0.05.

Results: Reliability analysis demonstrated high inter-day test-retest reliability for resting Achilles tendon length (ICC = 0.95), cross-sectional area (ICC = 0.96) and strain (ICC = 0.95). Tendon elongation measured with ultrasound imaging during peak isometric force had good reliability (ICC = 0.81). A moderate correlation was found between resting tendon length and the lunge test on each day of testing; Day 1 ($r=0.67$, $r^2=0.45$, $p=0.034$) and Day 2 ($r=0.66$, $r^2=0.44$, $p=0.038$).

Conclusion: Ultrasound imaging measurements of the material and mechanical properties of the Achilles tendon has good-to-high inter-day reliability in a single rater. It was also determined that Achilles tendon resting length accounted for ~45% of the variance in the lunge test, indicating other factors contribute to lunge test performance. The later may include talocrural and subtalar joint motion, and length of the gastrocnemius and soleus muscles.

Clinical relevance: Ultrasound imaging can be used as a reliable, safe and cost-effective tool to measure isolated Achilles tendon properties. This may allow future studies to explore intervention effects on the material and mechanical characteristics of the tendon.